CHAPTER 9

CHEMICAL MIXING

When light-sensitive emulsions are used, photography is essentially a chemical process. You depend upon the chemical process to produce visible and permanent images. An important requirement for optimum photographic processing is the careful and correct preparation of photographic solutions. Improper mixing of chemicals or contamination during mixing can have far-reaching effects on operations, quality, production, and mission accomplishment in the imaging facilities of the Navy. It is often difficult to determine the cause of poor quality when improper chemical mixing is at fault, and the need for discarding incorrectly prepared or contaminated solutions cuts down on production and wastes money.

The main function of the darkroom portion of the photographic process is to develop film and produce prints, and this requires photographic chemistry. It may be your job to ensure that all chemicals needed are mixed and checked for quality. "This is a responsibility that you cannot take lightly." A solution that is mixed improperly may cause an entire mission to be lost. You must use the utmost precautions when mixing, checking, or analyzing the photographic solutions used in your lab.

PHOTOGRAPHIC CHEMICAL AND SOLUTION STORAGE

When you receive chemicals in your imaging facility, the cartons, packages, or containers should be dated to show either the date received or the date shipped. This helps provide proper stock rotation and systematic control of chemical usage. Chemicals should be issued from the storeroom on a first-in-first-out (FIFO) basis.

Unmixed chemicals should be stored in their original, unopened containers in a cool, dry, well-ventilated storage area where the temperature is maintained at or about 75°F with a relative humidity of about 40 percent.

Prepared solutions, like dry chemicals, also must be protected from adverse conditions, especially oxidation and contamination. When the following recommendations are adhered to, most "unused" solutions stay in good condition for a reasonable period of time:

- Small amounts of replenisher and stock solutions are best kept in stoppered or screw-cap bottles. Glass bottles are best for developer and developer replenisher. Screw caps must be free of corrosion, foreign particles, cardboard inserts, and be airtight. Never interchange bottle tops from one bottle to another. A cap-to-bottle color or number code is suggested.

- When large bottles are used to store solutions, the air space in the bottle is increased each time the solution is removed. Since this increases the chance for oxidation, store solutions in small bottles instead. The entire contents of a small bottle can then be used at one time. However, a small air space should be left even in small bottles. This allows for varying solution volume due to temperature changes and keeps the cap from loosening or the bottle from bursting.

- When tanks are used for the storage of large volumes of solutions, they should have floating lids to protect the solutions from aerial oxidation Dust covers also should be used to cover the top of the tank. The tank, the lid, and the cap should be coded in such a way that they are reassembled with the correct parts.

- Always follow the storage and capacity recommendations of the manufacturer. They are packaged with the chemicals. Do not use chemicals that have been in storage too long.

- Before you use any solution, no matter how long it has been mixed or in storage, check it for discoloration. Each solution has its own "signature" or characteristic appearance; and any change from normal may be a sign that it will produce unsatisfactory results. Check both sides and the bottom of the tank for precipitates. If there are any, carefully stir the solution to redissolve them. When you are unsure of the quality of the solution, discard it.

Most photo-processing chemical formulations are based on both their photographic qualities and their chemical stability or keeping qualities, both on the shelf before mixing and as prepared solutions. After long-term storage, chemicals may lose some of their chemical activity.

MIXING, TESTING, AND STORING EQUIPMENT

The type of material, used for photographic chemical mixing, solution testing, storing, as well as film-handling equipment, must be considered before mixing chemicals. Materials commonly used in the construction of this equipment are Type 316 stainless steel, polyethylene, and glass. Related equipment, such as solution transfer lines, mixer shafts, impellers, and machine parts, are also made of these same materials.

Some metals are not suitable for use with photo solutions. Serious chemical fog and developer changes can be caused by tin, copper, brass, and bronze. Aluminum, lead, nickel, zinc, galvanized iron, and Monel, when used with developers and fixers, can be harmful to films and papers. When these metals are used, silver thiosulfate from the used fixer may stick to them. Even when the utensils are washed after being in the fixer, enough silver thiosulfate can be transferred to the developer in the next processing or mixing run to cause stain, fog, or changes to image tone.

Wooden paddles and other absorbent materials must not be used with photographic solutions. Once they have been used, it is almost impossible to wash them clean of absorbed chemicals.

MIXING CONTAINERS

Chemicals should always be mixed in cylindrical containers made of suitable materials, The size of the mixing container should be suitable for the amount of solution to be prepared. A small batch of solution should not be mixed in a large vessel that uses mechanical agitation because large amounts of air may be introduced, and splashing may occur. So, the mixing container, and for that matter, scales and graduates, should be sized to the quantities and volumes of solutions required.

GRADUATES

Graduates are used to measure liquids. Graduates are made in various sizes, calibrations, and of various materials. The units of measure of graduates are calibrated in the U.S. liquid measurement system of ounces, quarts, and gallons, and in the metric liquid measurement system of cubic centimeters, milliliters, and liters.

Glass is most commonly used for making graduates because it is NOT affected by most chemicals. Glass is also transparent and reasonably durable. Graduates are also made from plastic and stainless steel. When using graduates made of plastic, do not try to measure strong acids, such as sulfuric acid, which could cause severe damage. You must also be sure that the material the graduate is made of does not react with any of your photographic chemicals.

For accuracy in measuring liquids, graduates should be proportional in size to the quantity of solution being measured; for example, an 8-ounce graduate should be used instead of a 32-ounce graduate to measure 2 or 3 ounces.

When measuring a liquid in a glass graduate, hold it at eye level and pour the solution into it until the surface of the liquid reaches the correct mark. You will notice a curved surface on the top of the solution. This curved surface is called the “meniscus.” The correct amount is indicated by the lower of two visible lines of the meniscus (fig. 9-1). These two lines can be seen easily through the side of a glass graduate when it is held correctly. With an opaque graduate, such as stainless steel, the two lines can be seen by looking down into the graduate from an angle. Stop pouring the solution when the “lower line” of the liquid reaches the calibration mark. Major divisions are indicated by numbers on the graduate. Subdivisions are shown by calibration lines only. You must determine the value of the individual subdivisions; for example, the marked or numbered lines may indicate ounces and read in series of 10. When there is only one calibration line between each graduation of 10, then the value of the calibration line is 5.

THERMOMETERS

All chemical action takes place faster at high temperatures than at low temperatures. In the photographic process, when you mix or use a solution, you must know its temperature.

Thermometers are used to measure the temperature of the solution and may be made of glass or metal. The average glass thermometer consists of a bulb, containing either mercury or colored alcohol, attached to a capillary tube. This tube may be calibrated or it may be secured to a graduated scale. When you are reading a

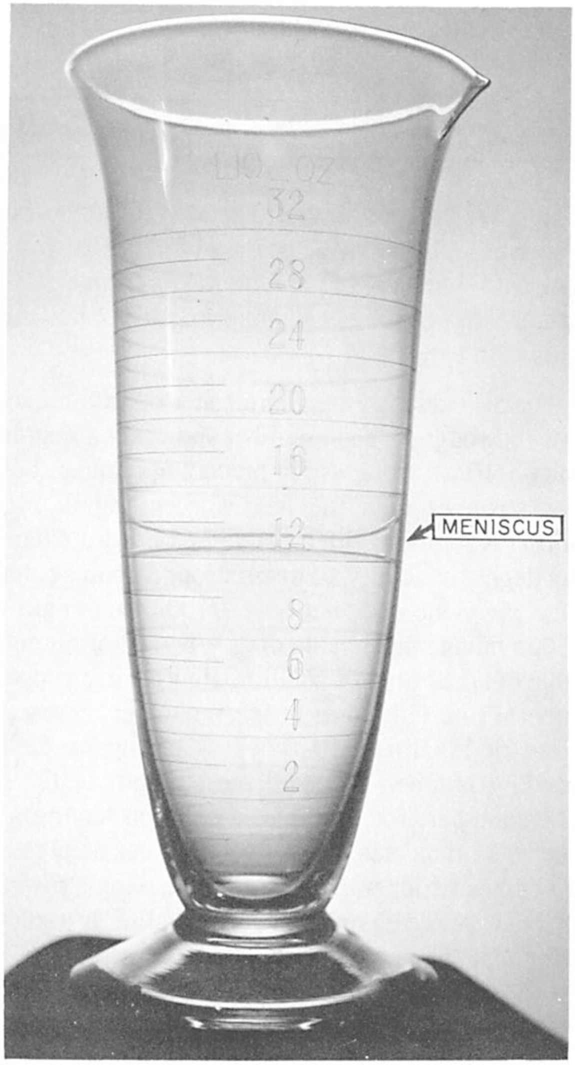

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Figure 9-1.–Read tbe lower line of the meniscus when measuring liquids

thermometer, your eyes should be level with the top of the liquid column in the capillary tube; otherwise, the reading may be off as much as 2 or 3 degrees. This error is due to the refraction of the cylindrical magnifier that is built into the capillary tube.

Most Navy photographic labs have metal, dial type of thermometers made of corrosion-resistant steel. They have a long, thin metal stem, or rod, with a circular dial indicator at the top. The action of this thermometer is remarkably fast, and the dial is easy to read.

The accuracy of all lab thermometers should be checked regularly against one of known accuracy, such as a Kodak process thermometer.

HYDROMETERS

Another measuring device used in photography is the hydrometer. A "hydrometer" is used to determine the specific gravity of a solution. A specific gravity check is one of the first tests to verify the dilution of a solution. When the same chemicals are used and when the same quantity of chemicals and an equal volume of water are used each time, the resulting liquid is approximately the same specific gravity each time. This is a characteristic of that particular solution when all specific gravity measurements are made at the same temperature.

The specific gravity should stay within an upper and a lower limit as determined by the manufacturer for each solution. Variations beyond the upper limit-indicating a denser or heavier liquid-suggest that more than the prescribed amount of one or more of the ingredients has been used, an ingredient foreign to the solution has been added, or not enough water was added to the solution. Measurements that fall below standard limits might indicate that something has been left out, that a foreign chemical has been substituted, or that more than the correct amount of water was added.

The silver content of a fixing bath increases as the bath becomes exhausted. This causes the specific gravity of the solution to rise. Hence, in addition to testing the consistency of chemical solutions, specific gravity tests may be used to check the amount of silver in the fixing bath. A hydrometer used for this purpose must be calibrated in grams of silver per liter of solution.

A hydrometer consists of a hollow tube with an enlarged lower section, or float, topped by a narrow stem. The lower section is weighted, so the hydrometer will float in liquids with its stem protruding from the surface. The stem is graduated with marks that are used to indicate the density of the liquid in which the hydrometer floats. When the density of the liquid is high, it supports the hydrometer more easily, so less of the stem is submerged. Less dense liquids allow the hydrometer to sink deeper.

Hydrometers are commonly graduated in terms of specific gravity. Specific gravity is the ratio of the density of a substance to the density of distilled water. However, hydrometers designed for special purposes have different types of graduated scales. An example is the hydrometer that is used to check the silver content of a fixing bath.

Because of the effects of surface tension and capillary action, a meniscus is formed at the interface between the solution and the hydrometer stem. The

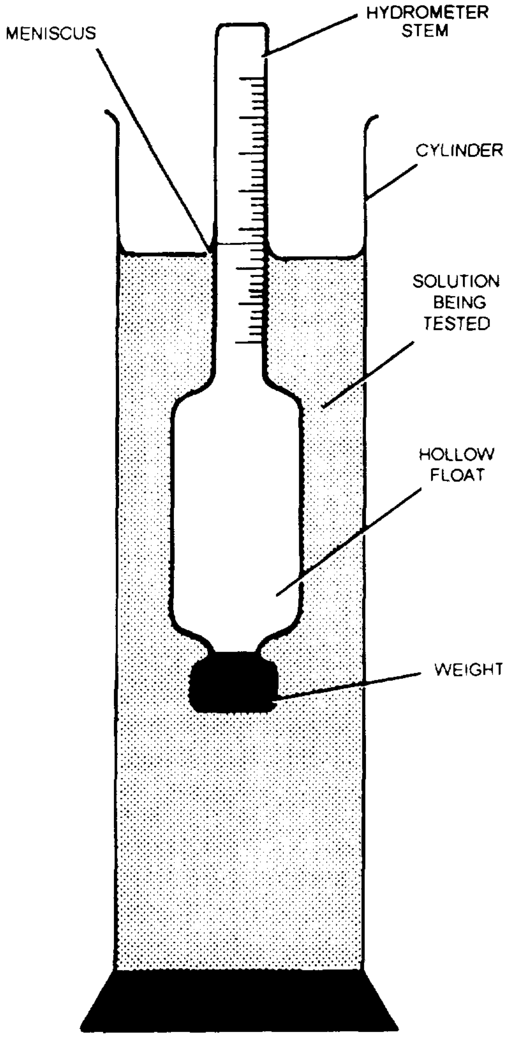


Figure 9-2.–Hydrometer.

reading is taken at the point where the top of the meniscus intersects the stem of the hydrometer (fig. 9-2).

pH METERS

The acid or alkali state of a solution is measured in pH values. The pH value of developers and fixers influences their activity and proper strength. pH is basically a measure of the degree of acidity or alkalinity of a solution. It provides an invaluable aid in determining the degree of accuracy with which the processing solutions have been prepared. Photographic developers usually have a pH of 8 to 12, while fixers range between pH 3.1 and 5.

The following scale indicates the location of acids and alkalis by their pH value (strength):

pH VALUES		
ACIDS	NEUTRAL	ALKALIS
1 2 3 4 5 6	7	8 9 10 11 12 13 14

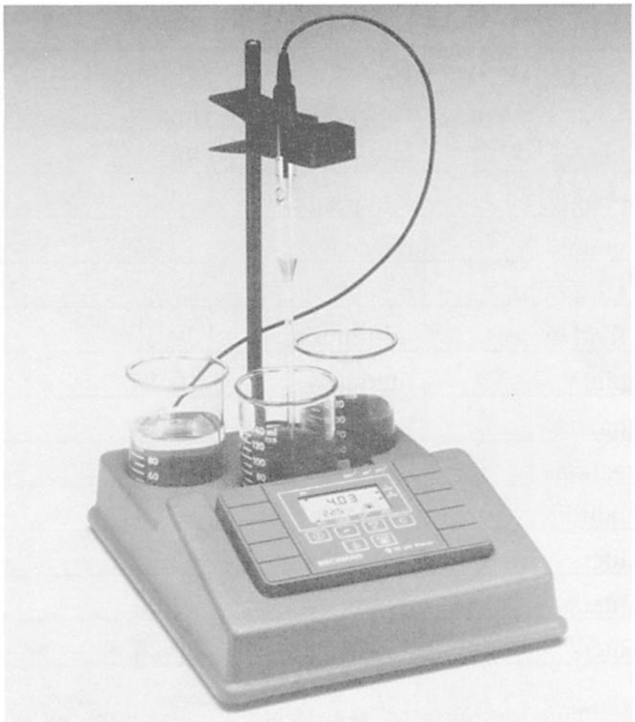
A pH of 7 is neutral. Working down from this point, the figures indicate weak acids with a pH of 6 on to strong acids with a pH of 1. Working up from a pH of 7, the figures indicate weak alkalis with a pH of 8 to strong alkalis with a pH of 14.

The pH values are numbered on a logarithmic scale. From 0 through 6, each number indicates a degree of acidity 1/10 as strong as the preceding number, but 10 times stronger than the next succeeding or higher number. A solution with a pH value of 4, for example, has a degree of acidity 10 times stronger than a solution with a pH value of 5, but only 1/100 the strength of a solution having a pH value of 2. When determining the degree of alkalinity of a solution, figure it in an opposite manner. From 8 through 14, each number represents a degree of alkalinity 10 times as strong as the last preceding number, but 1/10 the strength of the next higher number; for example, a solution having a pH value of 11 indicates that the solution has an alkalinity 1,000 times stronger than a solution having a pH value of 8, but it would be only 1/100 as alkaline as a solution having a pH value of 13.

Litmus paper is used to indicate whether a solution is acid, alkaline, or neutral, but it does not indicate the actual pH value. For this purpose a pH meter should be used.

A pH meter is an amplifier meter with a scale that reads from 0 to 14 and an electrode apparatus (Eg. 9-3). A pH meter has a reference electrode and a pH measuring electrode, or these two can be combined into one combination electrode. The pH electrode actually measures the pH, while the reference electrode that contains an electrolyte solution is used only to complete the electrical circuit. The first step in measuring pH is to establish a point of reference by a standardization procedure. To standardize the pH meter, you must place the electrodes in a calibrated buffer solution.

Buffer solutions are available at exact pH values for this precise standardization. Always select a buffer with a pH value as close as possible to the pH of the sample to be tested; for example, use a buffer at a pH of 4.00 to test a fixer solution or a pH of 10.00 to test a developer solution. The instrument should be standardized at regular intervals during a long series of measurements or before each use.



Courtesy of Beckman Instruments, Inc.
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Figure 9-3.–pH meter.

Courtesy of Kreonite, Inc.
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Figure 9-4.–Agitation mixers.

The ability of a pH meter to determine the pH value of a solution accurately may be used for the following purposes:

- To verify that chemicals have been properly mixed
- To test prepared chemicals
- To assure standardization of the processing solutions
- To determine the exact replenishment rates for photographic chemical solutions

Tolerances in pH values must be established for individual labs because of differences in procedures, types of equipment, impurities in water, and so forth. On the average, two readings from 10 different batches of each solution, mixed at different times, must be taken and recorded to establish these standards. These batches should be mixed as they would be for regular use but under very close control to ensure that the solutions are mixed at the correct temperature, in the proper sequence, and so forth. This operation helps in determining the tolerance. This tolerance is the amount of variation of the pH that still produces high-quality results.

The discussion of pH meters is intended as an introduction only. Detailed step-by-step operating instructions for pH meters are not included in this chapter. Operating instructions in the form of technical orders and manufacturer's manuals for specific pH meters will be available to you in your imaging facility.

MIXERS

In the Navy, we use two methods of mixing chemicals: hand mixing and machine mixing. Hand mixing is used when only small quantities of solutions are needed or when machines are not available. Machine mixing is necessary to handle the large production requirements of most Navy imaging facilities.

Agitation Mixers

Proper agitation of the solution during mixing increases the rate at which the chemicals are dissolved and prevents undesirable side effects. For proper agitation, an agitator type of mixer does not cause excessive amounts of air to enter into the solution (fig. 9-4). Developers are quickly ruined by oxidation; a few minutes of improper and violent agitation can weaken a developer and cause it to underdevelop and sometimes stain film. Too little agitation during mixing may cause the powdered chemicals to settle to the bottom of the mixer and form hard lumps. When these lumps of chemicals are undissolved and undetected, they can clog pumps and plumbing during transfer from the mixer to the storage tank. These lumps can also cause the solution to be less active.

Agitation mixers circulate solutions through a pump that causes a stirring action. There are several types of agitation mixers available. These include large capacity models for preparing large volumes of solutions and small models for making small amounts of solution.

Impeller Mixers

Impeller mixers provide thorough, rapid mixing, but they must be used with care to prevent frothing or foaming and introducing air into the solution. The solution must be mixed so a minimum amount of air is drawn into it. When the shaft is placed in the center of the container, the impeller causes a whirlpool effect that introduces excessive amounts of air into the solution. Furthermore, when the shaft is in the center of a container, there is very little agitation in the bottom-center area of the container and undissolved chemicals pile up directly beneath the end of the shaft (fig. 9-5).

Avoid bumping the shaft or impeller on the sides or bottom of the mixing vessel. This procedure may bend the mixer shaft, and a bent shaft produces excessive vibrations that can ruin the motor bearings.

WEIGHTS AND MEASURES

The different systems of weights and measures used in chemical mixing and the relationship of the various units to one another are matters that every photographer who prepares photographic solutions should understand.

These days, photographic chemicals are prepackaged and are usually published in two systems of weights and measures: avoirdupois and metric. In the avoirdupois system, chemicals are weighed in ounces and pounds and are dissolved in pints, quarts, or gallons of water. In the metric system, they are weighed in fractions or multiples of grams and are dissolved in cubic centimeters or liters of water. With a conversion table, a formula given in one system can be easily converted to the other.

Weight and Volume Conversion

Number of Units Known	Resultant Units	Multiplication Factor
ounces	grams	28.3
pounds	kilograms	0.45
grams	ounces	0.0353
kilograms	pounds	2.2
fluid ounces	milliliters	30
pints	liters	0.47
quarts	liters	0.95
gallons	liters	3.8
milliliters	fluid ounces	0.034
liters	pints	2.1
liters	quarts	1.06
liters	gallons	0.26

Two systems of temperature measurement are used: Fahrenheit and Celsius. The Fahrenheit scale uses °F as a temperature symbol. The Celsius scale uses °C as its symbol. On the Fahrenheit scale 32 degrees is the freezing point of water, and the boiling point is 212 degrees. The difference is 180 degrees. The Celsius scale is 0 to 100 degrees from freezing to boiling. One degree Fahrenheit is smaller than one degree Celsius, one Fahrenheit degree being 5/9 of a Celsius degree. To convert Fahrenheit degrees into Celsius, subtract 32, multiply by 5 and divide by 9; that is, $(°F - 32) \times 5/9 = °C$. To convert Celsius to Fahrenheit, multiply by 9, divide by 5, and add 32; that is, $(°C \times 9/5) + 32 = °F$.

Some formulas use the word *parts* as a measure. They may call for two parts of one chemical, one part of another, and any number of parts of water. This is frequently done when two or more stock solutions must be combined to make the working solution. In such cases, the word *parts* means any convenient "volume" measurement may be used; however, the same measure should be used for everything required by the formula. A part may be a fluid ounce or a gallon, depending upon the total quantity of working solution needed Formulas use parts only when volume is to be measured.

The term *stock solution* identifies a concentrated chemical solution. A working solution is the solution used for processing. The working solution may be the same as the stock solution, but more than likely it is a diluted stock solution.

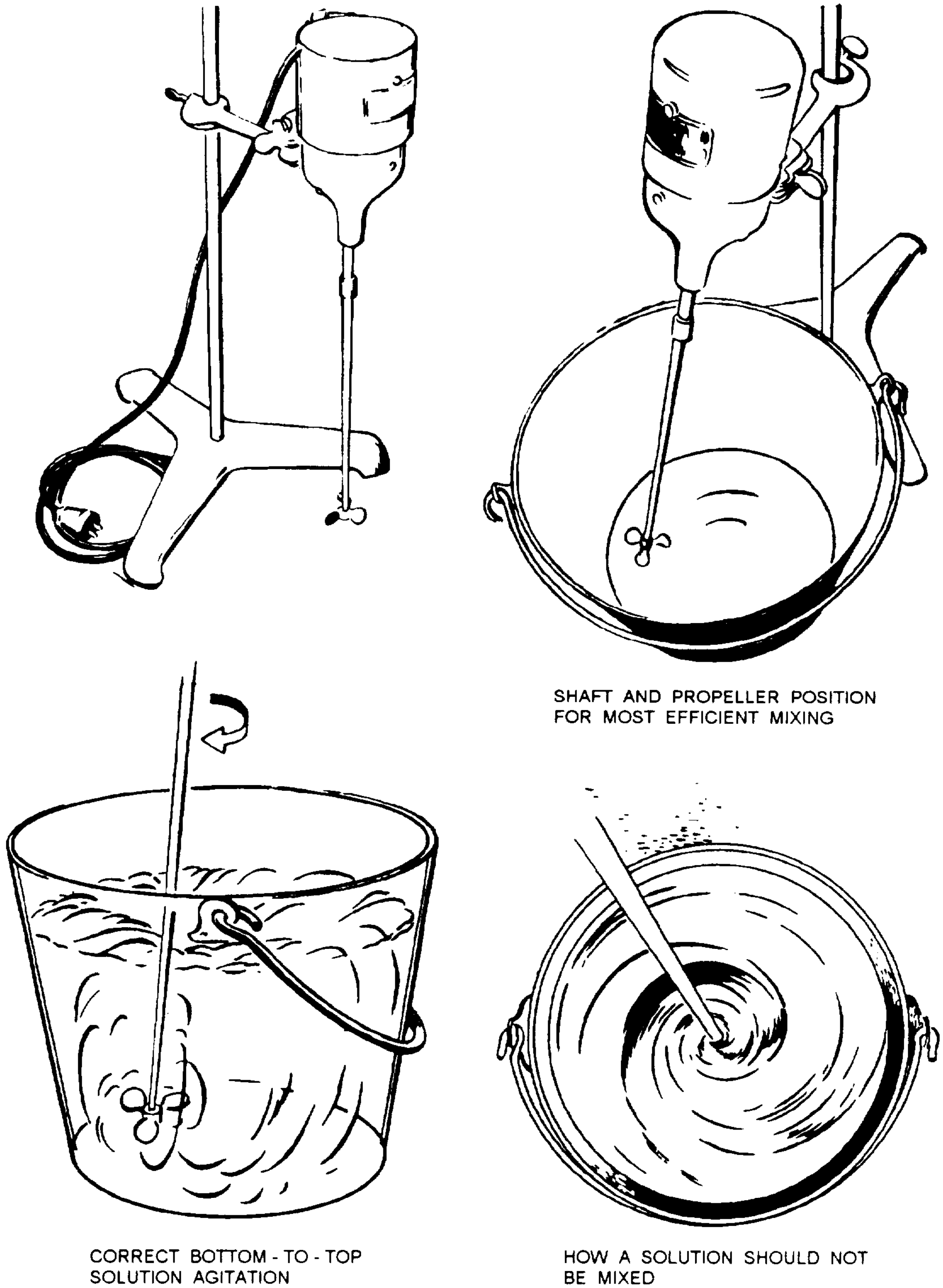

Figure 9-5.–Impeller mixers.

CHEMICAL MIXING RULES

For both personal safety and efficiency when mixing processing solutions, there are a few commonsense rules that you must follow. Mixing chemicals is simple enough, but even a slight error can change the working characteristics of some solutions. The principles of common cleanliness and precise measuring will prevent many chemical troubles. Without cleanliness and accuracy, many processes become guesswork.

Chemicals should not be mixed in areas where sensitized materials are handled or stored. Chemical dust or fumes can ruin these materials. There should be adequate ventilation, a complete air change every 3 minutes, and an exhaust fan to the outside atmosphere in the area where chemicals are mixed.

CONTAINERS

Containers for photographic solutions should be made of a material that does not affect or is not affected by chemicals. Glass is the best material. Stainless steel is a highly suitable material, provided it is of the proper composition. Hard rubber and glazed earthenware may also be used satisfactorily. Acid and alkali-resistant plastic containers are acceptable.

Containers, graduates, sinks, and every utensil used in the photographic lab should always be clean. As soon as work is finished with an item of equipment, it should be cleaned and returned to its proper place. When chemicals are spilled, clean them up as soon as possible.

Chemical solutions and chemical dust corrode and cause pitting of most materials, including stainless steel, when allowed to remain for any length of time.

ACCURACY

Photographic quality suffers when the chemicals are improperly mixed. You must be certain that the amount of chemical you put into a solution is the amount specified.

The mixing of processing solutions has been greatly simplified over the years by the introduction of packaged photo-processing chemicals. Packaged chemicals come in convenient sizes for most needs. They offer standardized quality, economy, and convenience.

Packaged chemicals include film and paper developers and fixing solutions of various types that are manufactured under tightly controlled conditions. These packaged chemicals are available in either liquid or powder form. Processing solutions can be mixed easier, faster, and more accurately with packaged chemicals than with bulk chemicals.

When mixing packaged chemicals, you should always mix the entire package. Packaged chemicals usually contain more than one ingredient. During shipping and handling, these ingredients may separate with the heavier elements settling to the bottom of the package. When only part of the package is mixed, some of the ingredients that have separated or settled may not be put into the solution and the result of the process is not predictable.

MIXING

Always add chemicals to the water or solution Dry chemicals should be poured slowly into the water while it is being stirred. When preparing a developer, be careful while you are stirring so air is not beaten into the solution. When water is poured on dry chemicals, they will cake and form hard lumps that are difficult to dissolve.

Lumps or hard particles should be ground up, or crushed, with the stirring rod or with a pestle. Never add another chemical to a solution before the previous part has been completely dissolved Sometimes there is a residue that will not dissolve. The residue may be sand in the water supply, impurities in the chemicals, or other matter that found its way into the water; however, when the solution is allowed to stand for awhile, these particles usually settle and the clear liquid can be poured off. To remove sludge or dust particles that may not settle, pour the solution through a funnel containing three or four layers of cheesecloth or absorbent cotton.

Many chemicals are very sensitive to heat, and even moderate temperatures seriously affect their chemical properties. However, the rate of chemical reaction increases with an increase in temperature, and all chemicals dissolve more readily in warm water than in cool water; consequently, many formulas and instructions recommend that water as hot as 125°F be used to prepare the solution that must then be cooled to the correct processing temperature. You should always try to mix solutions at the minimum temperature recommended by the manufacturer. Solutions oxidize faster at higher temperatures because of increased chemical activity at these temperatures.

When all crystals are dissolved, the solution should be practically colorless. Sometimes a solution appears cloudy or milky for a short time after it is mixed. This appearance may be caused by air taken into the solution by the dry chemicals. Air taken into a solution is distributed through the solution as tiny bubbles that cannot escape while the solution is being stirred. When the presence of bubbles has caused the discoloration, the solution will clear up when it is allowed to stand for a while. The bubbles rise to the surface of the solution and escape into the air.

Always add acid to the water. This is as easy to remember as AAA (Always Add Acid). It is dangerous to pour water into an acid. Some acids generate heat rapidly enough to cause boiling or a splashing explosion that may splash the solution on someone nearby. Acids should always be poured slowly into a solution (near the edge of the container) while rapidly but carefully stirring the liquid.

LABELS

Mixing tanks, storage tanks, and machine tanks for developer, stop bath, fixer, and other solutions must be labeled clearly with waterproof tape or nameplates to reduce the chance of putting a solution into the wrong tank. The label should contain the name of the solution, the date it was mixed, and the name of the person that mixed it. It is also mandatory that hazardous chemical labels be attached to all chemical containers.

CONTAMINATION

All of the mixing equipment and the mixing area must be cleaned immediately after use to prevent solution contamination. The mixing tools and tanks must be thoroughly cleaned right after use to prevent dried solutions from forming encrustations that could dissolve when a new solution is mixed. Mixing tools that have not been used in some time should be washed before use to remove any dust or dirt that may have accumulated.

PREPARATION OF PHOTOGRAPHIC SOLUTIONS

When mixing photo chemicals, you should always start with clean tools and a clean tank with the right amount of water-usually about one half to three fourths of the final volume. The temperature of the water must be as specified in the instructions. Developers are generally mixed at or about 90°F to 125°F, while fixers are mixed in water that should not be much above 80°F.

Always dissolve or dilute ingredients in the order called for by the instructions. Dry ingredients must be completely dissolved before the next ingredient is added. All liquids must be completely diluted, while stirring, before the next ingredient is added.

After a liquid is added to a solution, rinse the bottle and add the rinse water to the solution, so all the concentrated liquid is used.

After all ingredients have been combined and thoroughly dissolved, diluted, and mixed, water should be added to bring the solution up to the correct volume. Do not forget to mix this water thoroughly into the solution.

FOLLOW DIRECTIONS

Before mixing photographic chemicals, you should read the manufacturer’s directions carefully. Much research goes into the production of chemical products; however, it is only effective when the chemical is mixed and used properly. The directions for even the most familiar product should be reviewed, because there are continual attempts to improve photographic materials; for example, new film or developer combinations may call for changes in dilution, processing time, or temperature to get the required results. Learn to follow directions. This is very important in the preparation of chemicals for both quality and safety reasons.

Remember to follow the proper procedures for chemical safety. You should prepare the chemicals in a well-lighted and well-ventilated room. Do not taste or inhale any chemical. You are required to wear rubber gloves, a rubber apron, eye protection, a long sleeve shirt, and a respirator for your personal protection. Remember, for safe mixing and quality results, FOLLOW DIRECTIONS.

CAUTION

In most imaging facilities, it is common practice to connect a hose to the water spigot to aid in filling a chemical mixing tank and to prevent splashing in the sink. Aboard ship, hoses attached to potable water spigots can back siphon chemicals from the tank or sink into the drinking water supply. Such hoses should either be removed after each use or have a backflow preventor installed in the plumbing system.

CHANGING PERCENTAGES

You must know how to prepare percentage solutions from liquid chemicals. When the chemical on hand is in liquid form and of known strength, a percentage solution can easily be prepared by the following method:

$$\frac{\text{Amount Wanted x Strength Desired}}{\text{Strength on Hand}}$$

Multiply the amount wanted by the strength desired and divide the product by the strength of the chemical on hand; for example, you need 11 ounces of 28 percent acetic acid. The chemical on hand is glacial acetic acid, 99.5 percent. Thus,

$$\frac{11 \times 28}{99.5} = \frac{308}{99.5} = 3.09 = 3 \textit{ ounces}$$

Add 3 ounces of 99.5 glacial acetic acid to 8 ounces of water to obtain 11 ounces of a 28 percent solution of acetic acid.

CHEMICAL SAFETY

Some of the chemicals used in photography are skin irritants, and others can cause serious injuries. Chemicals should be regarded as poisons and handled with caution. Before handling or working with photographic chemicals, you should become familiar with the safety precautions contained in Navy *Occupational Safety and Health (NAVOSH) Program Manual for Forces Afloat,* OPNAVINST 5100.19 series, volume I (chapters B3 and B12) and volume II (chapters C1, C9, and C23), *Navy Occupational Safety and Health (NAVOSH) Program Manual,* OPNAVINST 5100.23 series (chapters 15, 20, and app. 15), and *Safety Precautions for Photographic Personnel,* NAVAIR 10-1-764.

Because of the danger of contaminating your fingers, all precautions concerning poisons should be observed when you are mixing photographic solutions.

Ingestion of a poisonous chemical is commonly induced by hands that are contaminated with a toxic chemical. You should adhere to the precautions published for photographic chemicals to avoid contact or ingestion of poisonous or corrosive chemicals. Regardless of the antidote given to anyone that has been accidentally exposed to or has swallowed a poisonous or corrosive chemical, the antidote is for EMERGENCY USE ONLY. The affected person should report to the MEDICAL DEPARTMENT IMMEDIATELY.

ACIDS AND ALKALIES

There are many types of acids and alkalies used in photography. In general, acids and alkalies are similar in their injurious properties in that either may cause the following:

- Corrosion (chemical burn) by direct contact with the skin or eyes or indirectly through the clothing.
- Intoxication or suffocation by inhalation of their fumes. The fumes of some compounds are toxic or poisonous, while others displace air, thereby producing a suffocating atmosphere.
- Poisoning when taken internally.
- Fire and explosion because of their instability under adverse storage conditions. Also, some acids are strong oxidizing agents that can generate ignition temperatures upon contact with organic materials and other chemicals.

PRECAUTIONS

There are several safety items that must be worn when mixing chemicals. They are as follows:

1. Face shield or goggles-Protects the eyes from caustic chemicals.
2. Plastic or rubber apron-Reduces the chance of chemical contamination of clothing.
3. Rubber gloves-Protects the hands and lower arms. Gloves should extend up to the elbows.
4. Respirators-Used to prevent the inhalation of fumes or chemical dust. The correct cartridge must be used for the type of chemical being mixed as described in *Navy Occupational Safety and Health (NAVOSH) Program Manual,* OPNAVINST 5100.23 series (app. 15). Respirators must be cleaned and sanitized with alcohol and placed in an airtight bag after each use.
5. Long sleeve shirt-Used to protect the arms.

The majority of photographic chemicals cause the skin to dry out due to the removal of natural skin oils. Some types of chemistry have an accumulative nature. This is when some of the chemicals are being absorbed into the skin layers during each exposure to the chemistry. The chemistry then replaces some of the natural oils that lubricate the skin. Over an extended period of time, which varies for different people, accumulation could result in a total breakdown of the ability of the skin to produce natural fats and lubricating oils. Extreme conditions can result in contact dermatitis. Metol (developing agent) poisoning can be a result of accumulation poisoning.

Certain precautions must be observed in areas where acids and strong alkalies are handled. These precautions are as follows:

- Warning signs and labels-Signs should be posted in the chemical mixing area, warning personnel of the principal hazards of the chemical being used. All containers must be properly identified with hazardous material labels.
- Showers and eyewash stations-Showers and eyewash stations must be provided near all chemical mixing areas.

- Ventilation-In a chemical mixing area, exhaust ventilation must be provided The exhaust vent must draw vapors away from the person mixing the chemicals and provide a complete air change once every 3 minutes (20 changes per hour).

- Mixing and diluting-Strong acids and strong oxidizing agents may react violently or produce explosive products. Toxic gases may be created when acid is mixed with such chemicals as sulfides, cyanides, nitrates, and nitrites. Diluting acids with water can generate considerable heat; acid should always be added to water, not water to acid. The addition should be done slowly with constant stirring.

- Never smell a chemical directly from the bottle; instead, hold the bottle at a distance from your nose and sniff its contents cautiously rather than inhale directly.

- Never taste a chemical.

- Handle all chemicals cautiously; many can produce burns or skin irritation.

MATERIAL SAFETY DATA SHEETS (MSDS)

In addition to the precautions listed previously, every person in your imaging facility must be completely familiar with the Material Safety Data Sheets (MSDS) for each chemical solution used in your photographic production. The MSDS are provided by all the manufacturers of hazardous materials. You are required to have the MSDS for each solution. The Occupational Safety and Health Administration (OSHA), as well as your safety officer, performs periodic safety inspections of your imaging facility. Every person is responsible for the location and information contained in the MSDS. MSDS are generally broken down into 12 sections as follows:

1. Product Information
2. Component Information
3. Precautionary Label Statements
4. Physical Data
5. Fire and Explosion Hazard
6. Reactivity Data
7. Toxicological Properties
8. Protection and Preventive Measures
9. Storage and Disposal
10. First Aid
11. Transportation
12. Preparation Information

It should be noted that separate MSDS may apply to working solutions and stock solutions or concentrates. Be certain that the MSDS apply to the chemical you are in contact with.

ENVIRONMENTAL ISSUES

The Environmental Protection Agency (EPA) has tightened regulations drastically and they have a substantial impact on the way imaging facilities conduct business. All Hazardous Materials (HAZMAT) must be handled in complete compliance with EPA regulations. The regulations and tolerances differ from state to state and base to base. It is important that you comply with the regulations in your local area

DISPOSING OF HAZARDOUS MATERIALS

Before you pour photographic chemicals down the drain or throw material in the dumpster or over the side, you must be certain that you are not violating any hazardous material handling or disposal procedures. You should be completely familiar with the environmental protection standards and the Ship's Hazardous Material List for all items that apply to your command. EPA regulations state that anyone violating environmental protection regulations can be personally accountable and fined. When you have ANY doubt, ask your supervisor before disposing of the material(s).

The MSDS provide information on how to neutralize and clean up spill containment of photographic chemicals. When handling and cleaning up chemical spills, be sure you follow all safety precautions mentioned previously. It is important that any chemical spill be cleaned up immediately because many chemicals are extremely corrosive. These chemicals may damage or stain the surfaces with which they come into contact. Consult your local directives on disposing of materials used to clean up chemical spills as well as the chemicals themselves.

SILVER RECOVERY

Silver contained in photographic emulsions and used fixers and bleaches are considered hazardous material. Silver recovery was established originally to reclaim the silver from these materials and reclaim for money that was returned to the Department of Defense. Today, however, when not performed, silver recovery could be very costly in the fines that may occur when photographic materials are not disposed of properly. Be certain that you know the proper handling procedures for photographic materials that contain silver.